

# *THE “KARLSRUHER NUKLIDKARTE” HISTORY*

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<http://www.karlsruhenuclidechart.net>

*"It is clear that science progresses through the interplay of ideas, with contributions from so many different viewpoints and approaches. [...] It is the very essence of science that it is common for all mankind. The feeling of an international community on a world-wide scale that we have encountered has given an added dimension to our lives."*

**B.R. Mottelson, Nobel banquet Speech, 1975**

Bridge between nuclear  
Science communities

➡ Scientists

➡ Users



A. Bohr and B.R. Mottelson

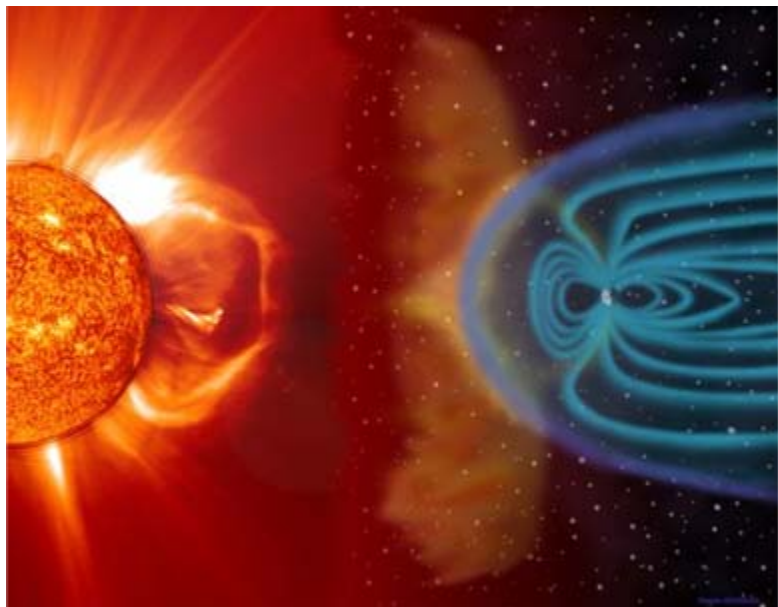
***Made by teachers***

***More than 350000 copies sold over 50 years ⇒ Impact?***

***Widespread applications of Nuclear data and nuclear techniques***

***Carbon dating or Astrophysics: Where we come from?***

***Knowledge dissemination and scientific popularization***



Solar eruption and Cosmic Rays

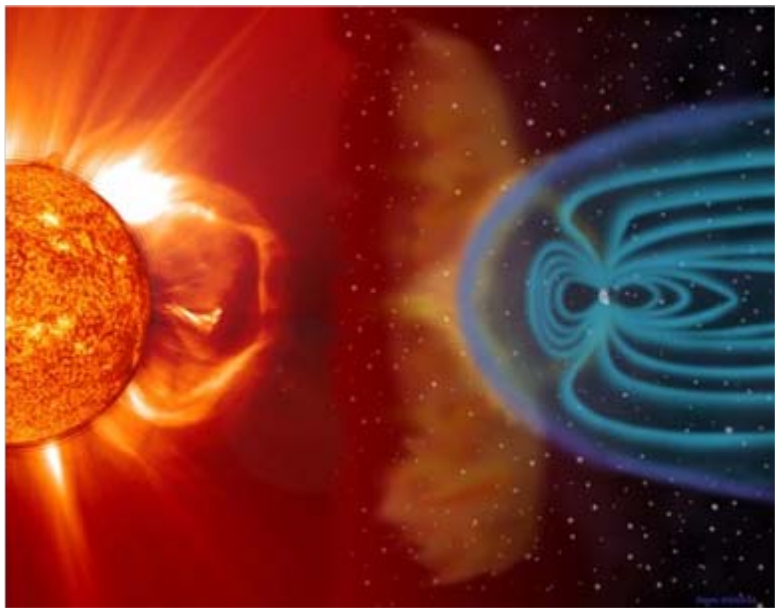
➡ Unpredicted and unexpected facts ➡



***” Physics is an incredible rich discipline: it not only provides us with the basic understanding of the laws of nature, it also provides the basis of most of modern high-technology.”***

**Abdus Salam, *The New Physics*, 1998**

➡ Particle trajectories



Solar eruption and Earth magnetic field

➡ Nuclear reactions



NGC 3184 in the constellation  
Ursa Major

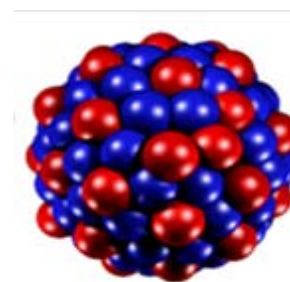
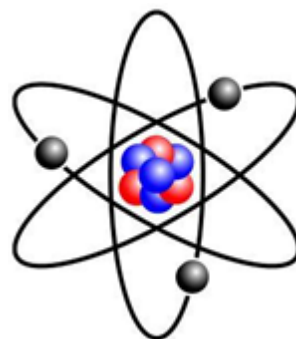
➡ Dating



Gruaud-Larose expertise

## Description of Atomic and Subatomic systems

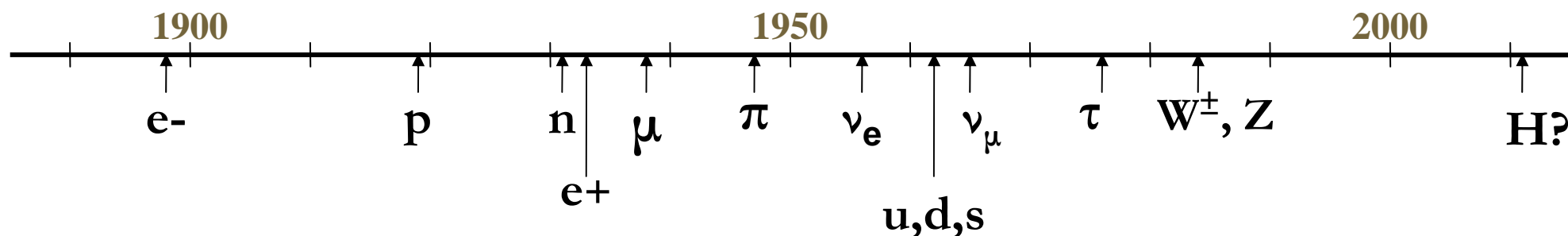
- ➔ Electronic structure of the atoms
- ➔ Proton and neutron system
- ➔ Parton (Quark) structure



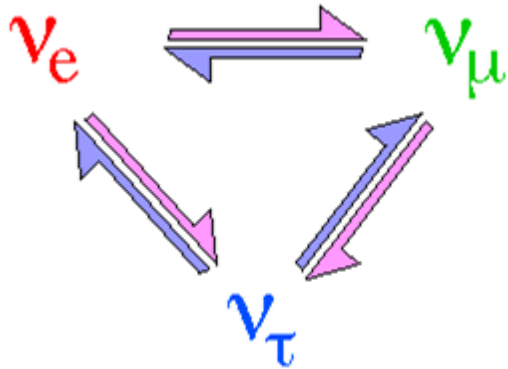
**Stardust?**

**Natural and artificial nuclides**

*“Its ultimate acceptance took well over a decade and occurred only after inescapable and compelling experimental evidence.” J.I. Friedman*







Offener Brief an die Gruppe der Radioaktiven bei der  
Gauvereins-Tagung zu Tübingen.

Abschrift

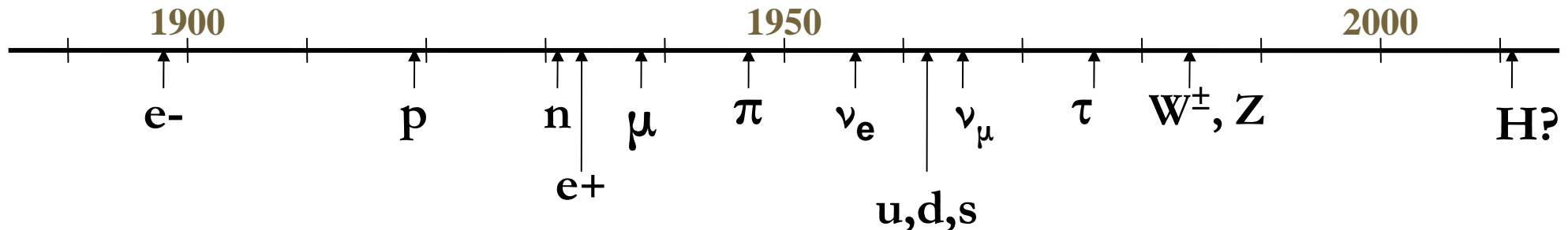
Physikalisches Institut  
der Eidg. Technischen Hochschule  
Zürich

Zürich, 4. Des. 1930  
Oliverstrasse

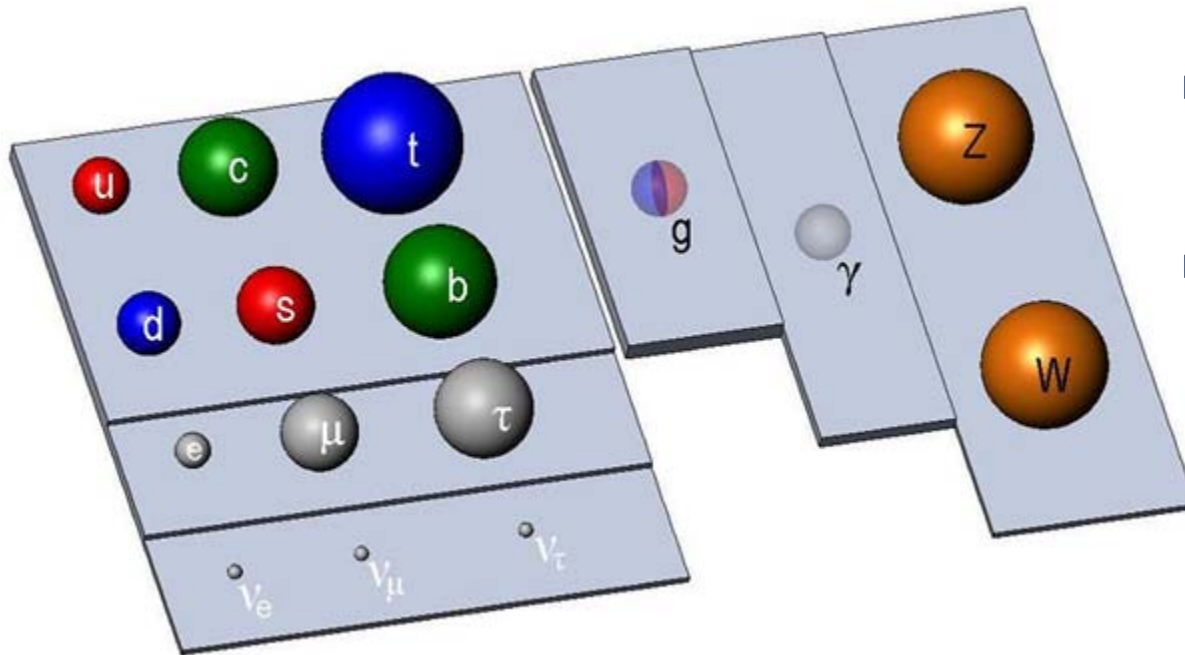
Liebe Radioaktive Damen und Herren,

Wie der Ueberbringer dieser Zeilen, den ich halbvollst  
anzuhören bitte, Ihnen das näheren auseinanderzusetzen wird, bin ich  
angesichts der "falschen" Statistik der N- und Li-6 Kerne, sowie  
des kontinuierlichen beta-Spektrums auf einen verzweifelten Ausweg  
verfallen um den "Wechselssatz" (1) der Statistik und den Energiesatz  
zu retten. Nämlich die Möglichkeit, es könnten elektrisch neutrale  
Teilchen, die ich Neutronen nennen will, in den Kernen existieren,  
welche den Spin 1/2 haben und das Anschliessungsprinzip befolgen und  
sich von Lichtquanten ausserdem noch dadurch unterscheiden, dass sie  
nicht mit Lichtgeschwindigkeit laufen. Die Masse der Neutronen  
musste von derselben Grössenordnung wie die Elektronenmasse sein und  
jedemfalls nicht grösser als 0,01 Protonenmasse. Das kontinuierliche  
beta-Spektrum wäre dann verständlich unter der Annahme, dass beim  
beta-Zerfall mit dem Elektron jeweils noch ein Neutron emittiert  
wird, derart, dass die Summe der Energien von Neutron und Elektron  
konstant ist.

- ⇒ Neutrino: postulated in 1930
- ⇒ Discovered in 1956
- ⇒ KATRIN, KAMIOKANDA, ...



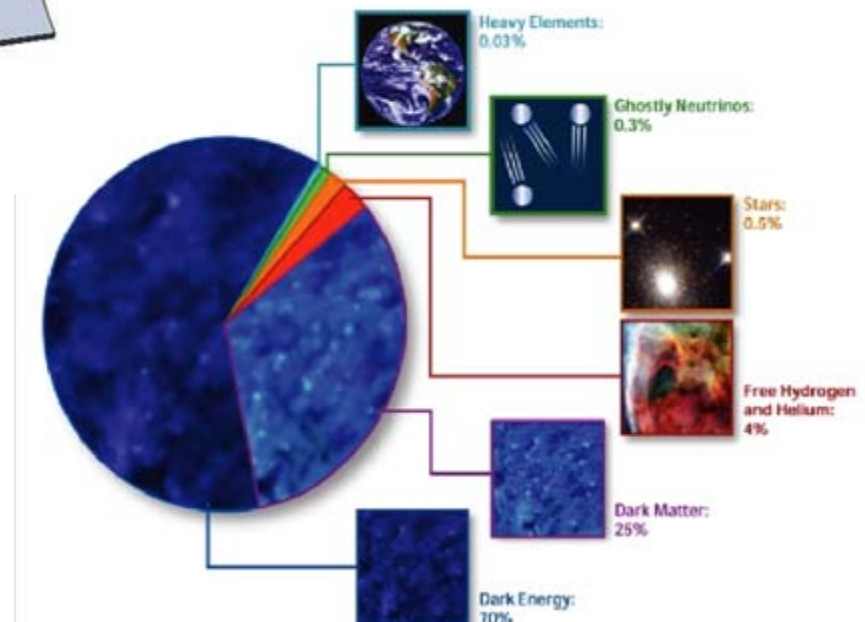
## Matter can be described through combinations of some elementary particles

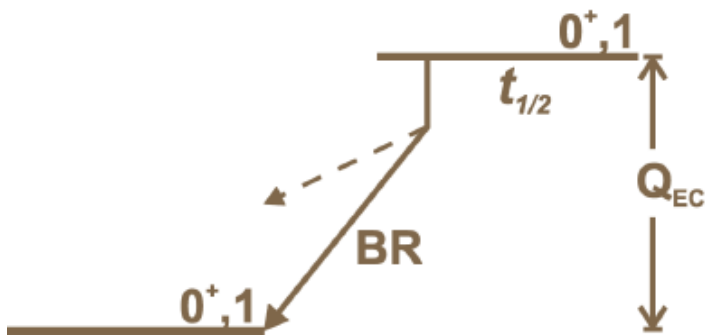


➔ Quarks "up" and "down"  
protons and neutrons

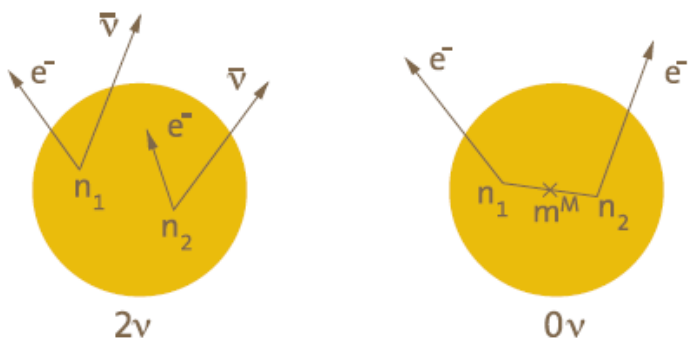
➔ Leptons  
electrons and neutrinos

- ➔ Additional quarks: hypernucleides with strange quarks
- ➔ Antiparticles: Antimatter?
- ➔ Missing mass of the Universe: Dark Matter? SUSY?

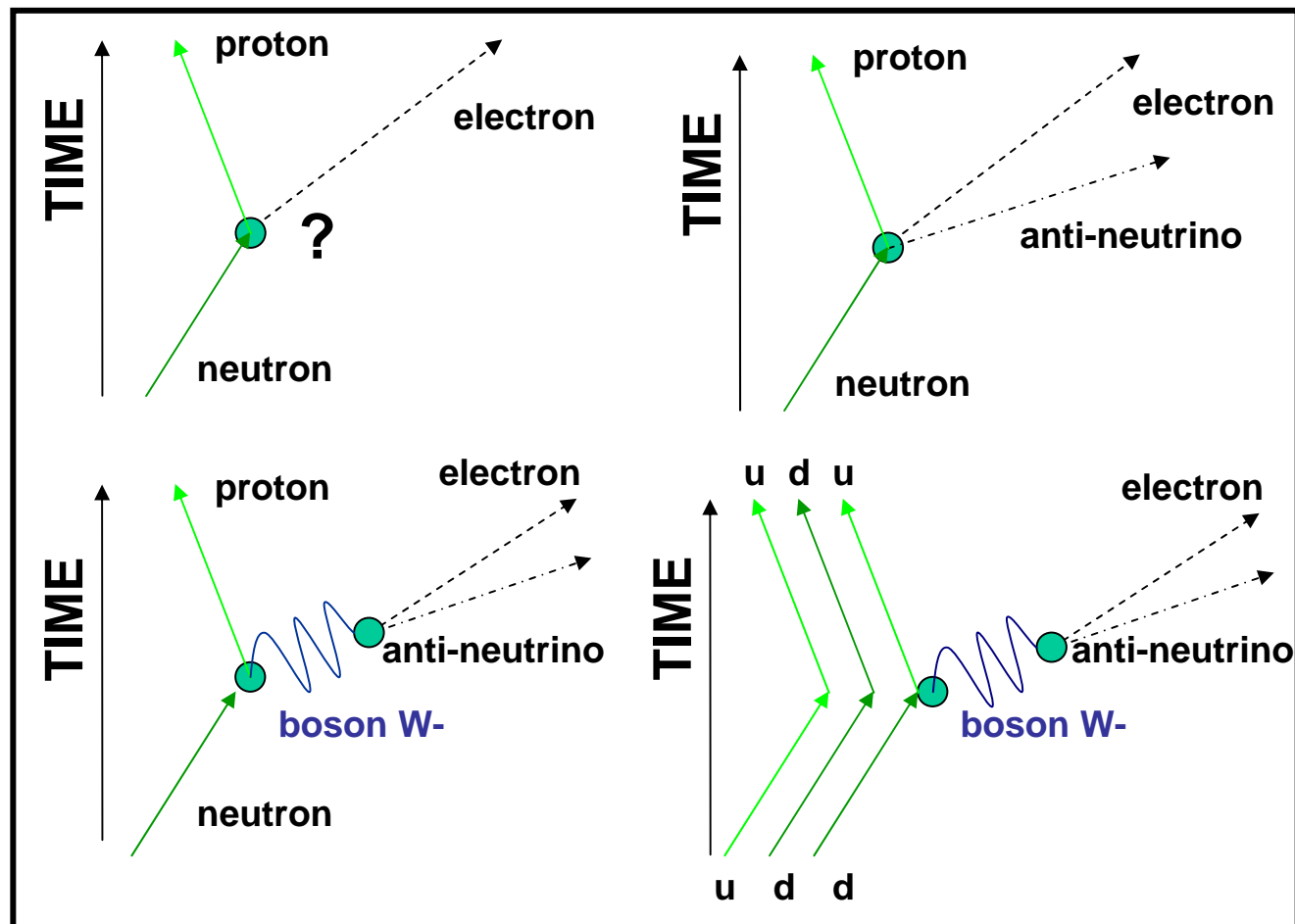




Super-allowed beta decay:  
CKM matrix test

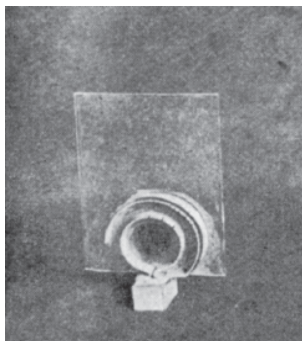


➔ Double beta decay  
"neutrinoless"



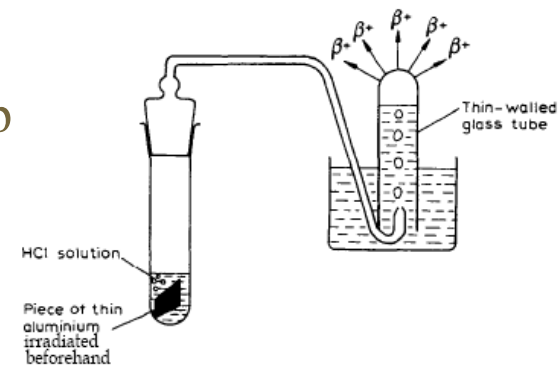
- ➔ Non pre-existing particle
- ➔ Beta decay of ionized nuclides
- ➔ Beta delayed emissions





Becquerel  
photographic plate

Joliot-Curies set-up



- ➔ Beam development  
RIB
- ➔ Detection techniques  
Multidetectors

GSI (Storage Ring)



KATRIN

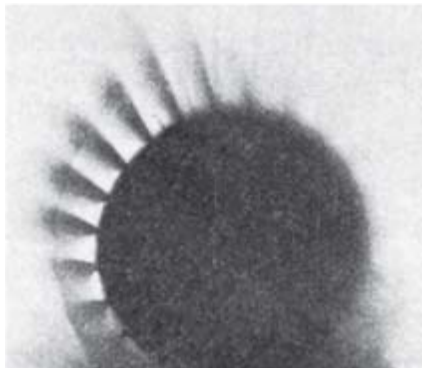


1																18																																															
1 H		2										13										14										15										16										17										2 He	
3 Li		4 Be												5 B		6 C		7 N		8 O		9 F		10 Ne																																							
11 Na		12 Mg		3		4		5		6		7		8		9		10		11		12		13 Al		14 Si		15 P		16 S		17 Cl		18 Ar																													
19 K		20 Ca		21 Sc		22 Ti		23 V		24 Cr		25 Mn		26 Fe		27 Co		28 Ni		29 Cu		30 Zn		31 Ga		32 Ge		33 As		34 Se		35 Br		36 Kr																													
37 Rb		38 Sr		39 Y		40 Zr		41 Nb		42 Mo		43 Tc		44 Ru		45 Rh		46 Pd		47 Ag		48 Cd		49 In		50 Sn		51 Sb		52 Te		53 I		54 Xe																													
55 Cs		56 Ba		57-71 La		72 Hf		73 Ta		74 W		75 Re		76 Os		77 Ir		78 Pt		79 Au		80 Hg		81 Tl		82 Pb		83 Bi		84 Po		85 At		86 Rn																													
87 Fr		88 Ra		89-103 Ac		104 Rf		105 Db		106 Sg		107 Bh		108 Hs		109 Mt		110 Ds		111 Rg		112		113		114		115		116		(117)		118																													
(119)		(120)		(121-153)		(154)		(155)		(156)		(157)		(158)		(159)		(160)		(161)		(162)		(163)		(164)		(165)		(166)		(167)		(168)																													

Lanthanides	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
Actinides	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr
Super-Actinides	(121)	(122)	(123)	(124)											(153)



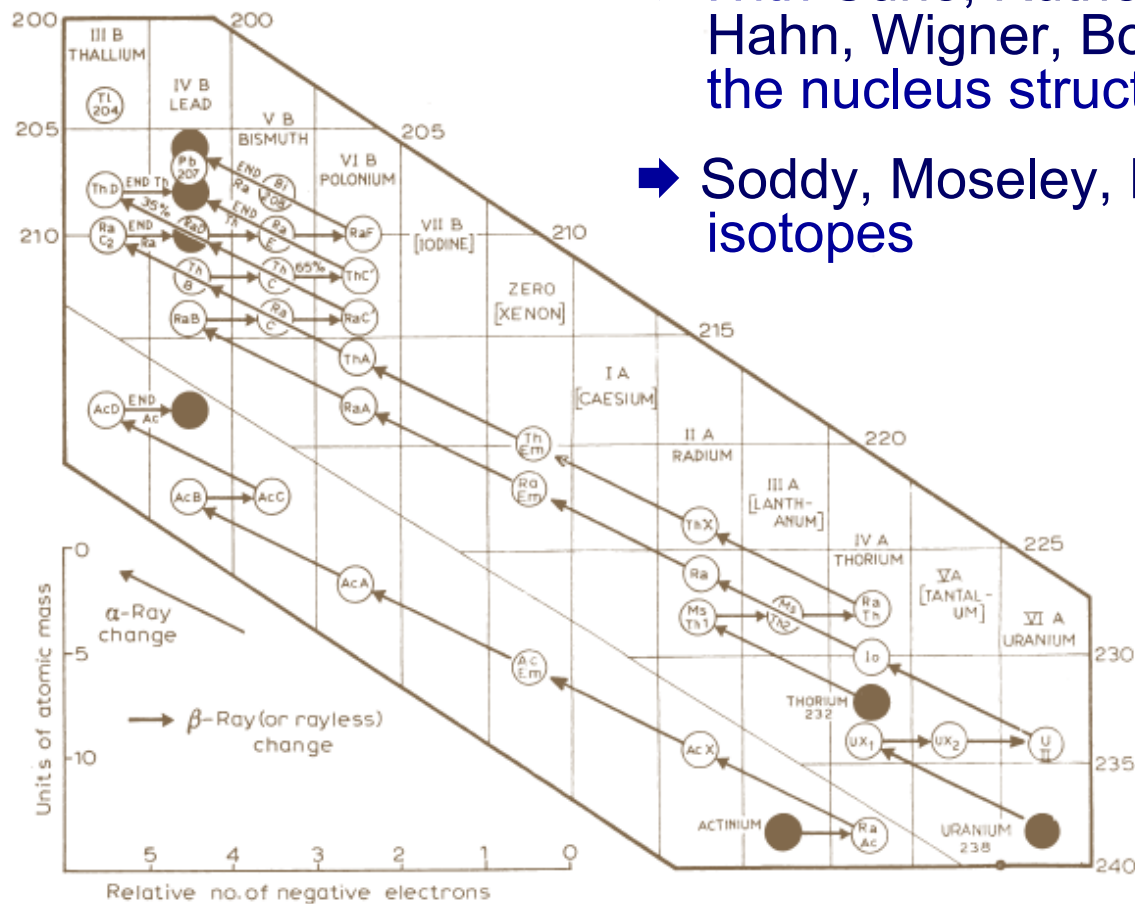
➡ Mendeleyev table 1869,  
Chemical properties, Mass  
Number



➡ H.Becquerel 1896, discovery of radioactivity



- ➔ With Curie, Rutherford, Fermi, Hahn, Wigner, Bohr, knowledge of the nucleus structure
- ➔ Soddy, Moseley, De Hevesy, isotopes



F. Soddy



H. Moseley

Radio-elements and Periodic Law. The neutron was not discovered yet.



Representation of nuclides in a proton/neutron map system (Fea 1935, Seaborg, 1940, Segrè 1945)



G.T. Seaborg, 1951



E. Fermi and E. Segrè

- ➡ Segrè chart: Exploration of the Chart done in the Fermi team with the production of artificial nuclides



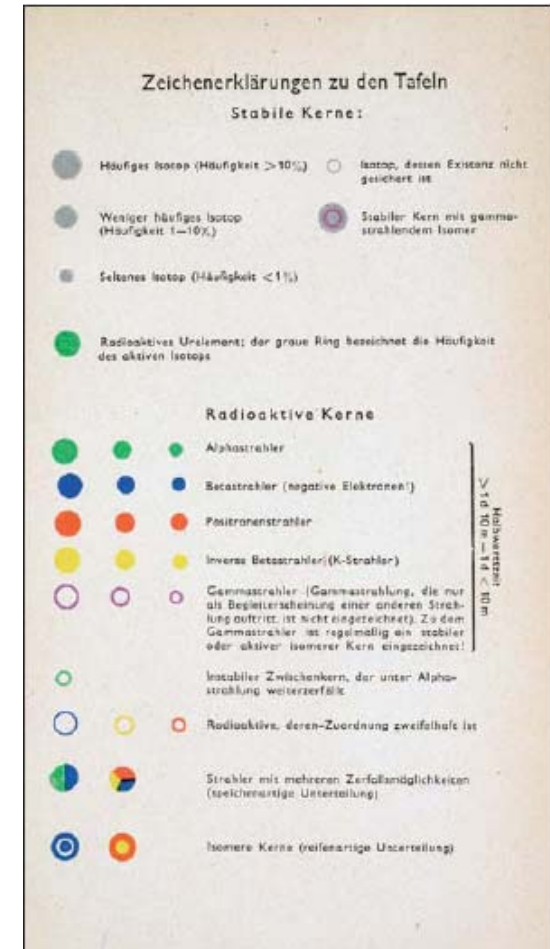
*Popular Science*, March 1948

*“US Alchemists Make Gold”*

785 entries for 96 elements

“All are combinations of only two ingredients, protons and neutrons”

W. Riezler, *Tabellen und Tafeln zur Kernphysik*, Ergänzungsband zur Einführung in die Kernphysik, Bibliographisches Institut, Leipzig, 1942



“Recent experiments indicate that a trace of radioactive carbon 14 is normally present in the human body”







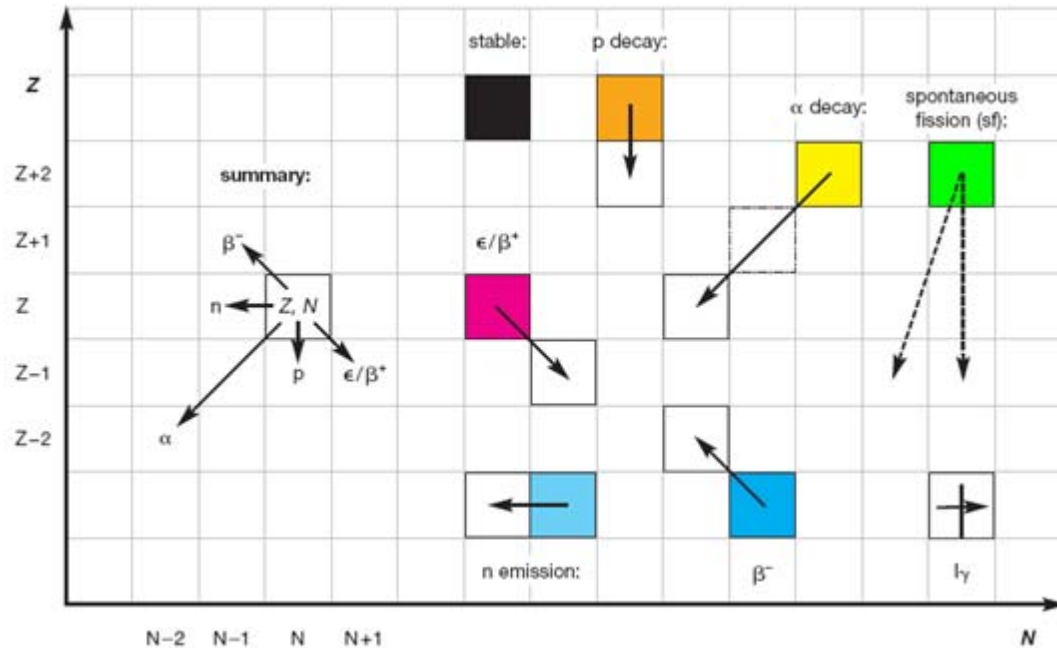
Wall of “Nuclear knowledge” in FZK



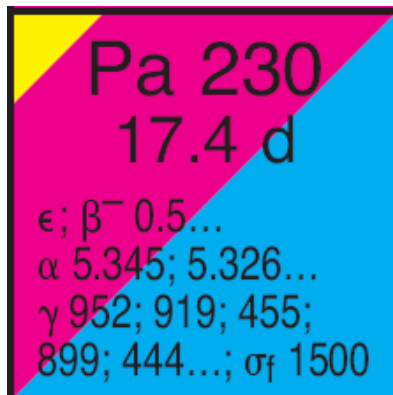
W. Seelmann-Eggebert

“El profesor alemán”

- ➡ 1958 first edition of the “Karlsruher Nuklidkarte” W. Seelmann-Eggebert and G. Pfennig from the Karlsruhe Radiochemical Institute.
- ➡ 267 stable and 1030 radionuclides for 4 decay modes



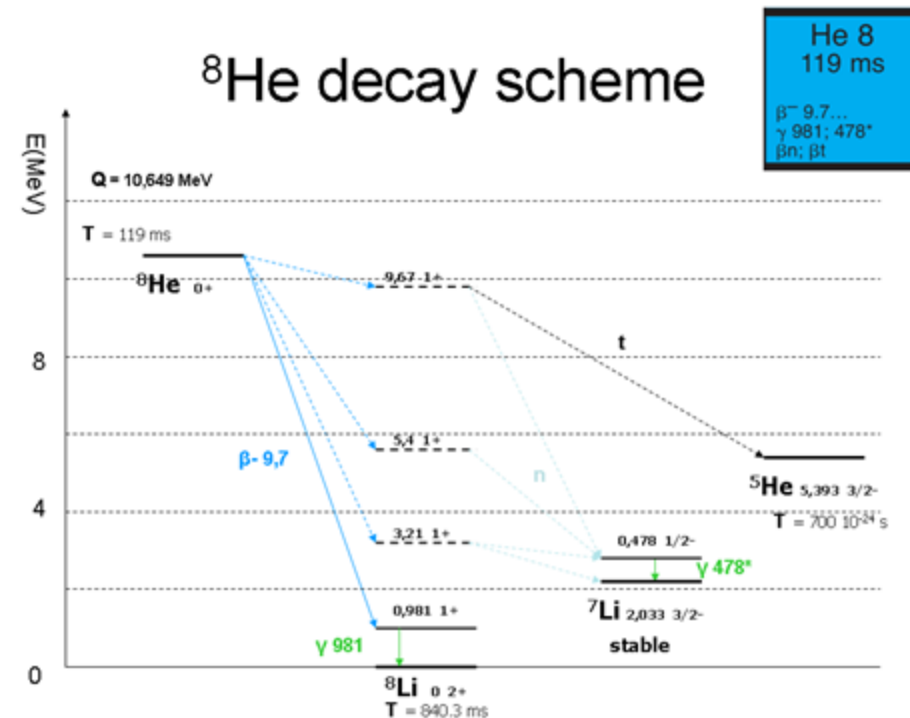
Colours  $\longleftrightarrow$  Decay Modes



Branching ratios



Coloured areas



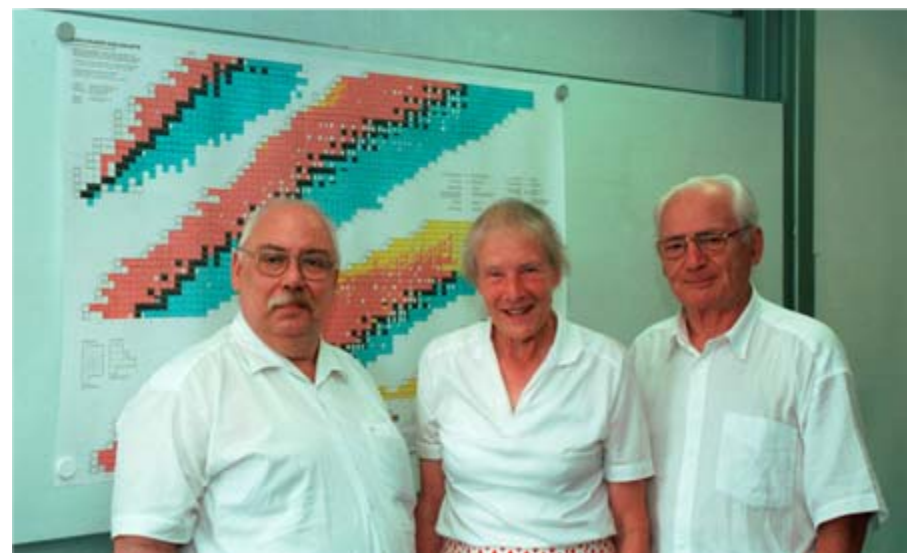


G. Pfennig and W. Seelmann-Eggebert, the first two authors of the Karlsruher Nuklidkarte with G.T. Seaborg, Nobel Prize winner 1951



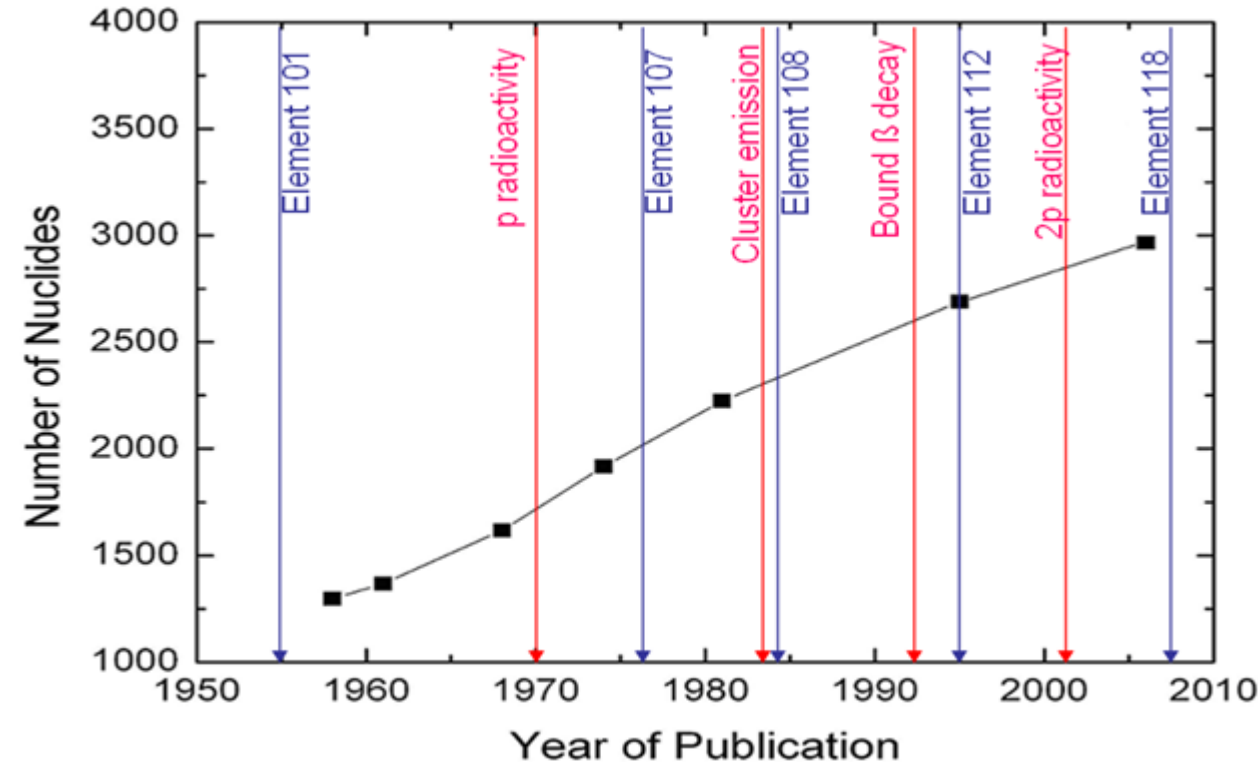
J. Galy, J. Magill, G. Pfennig (2008)

Since the first edition from 1958 to 2008, 7 authors had worked on the different editions.



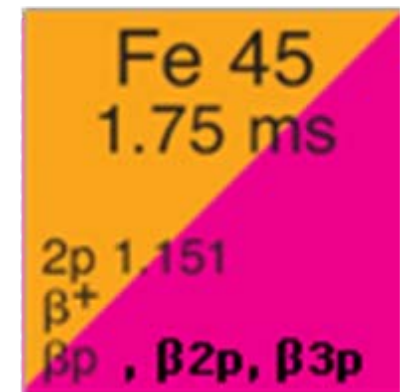
H. Klebe-Nebenius, G. Pfennig and H. Münzel

G. Zündel took part to the 2<sup>nd</sup> edition (1961).

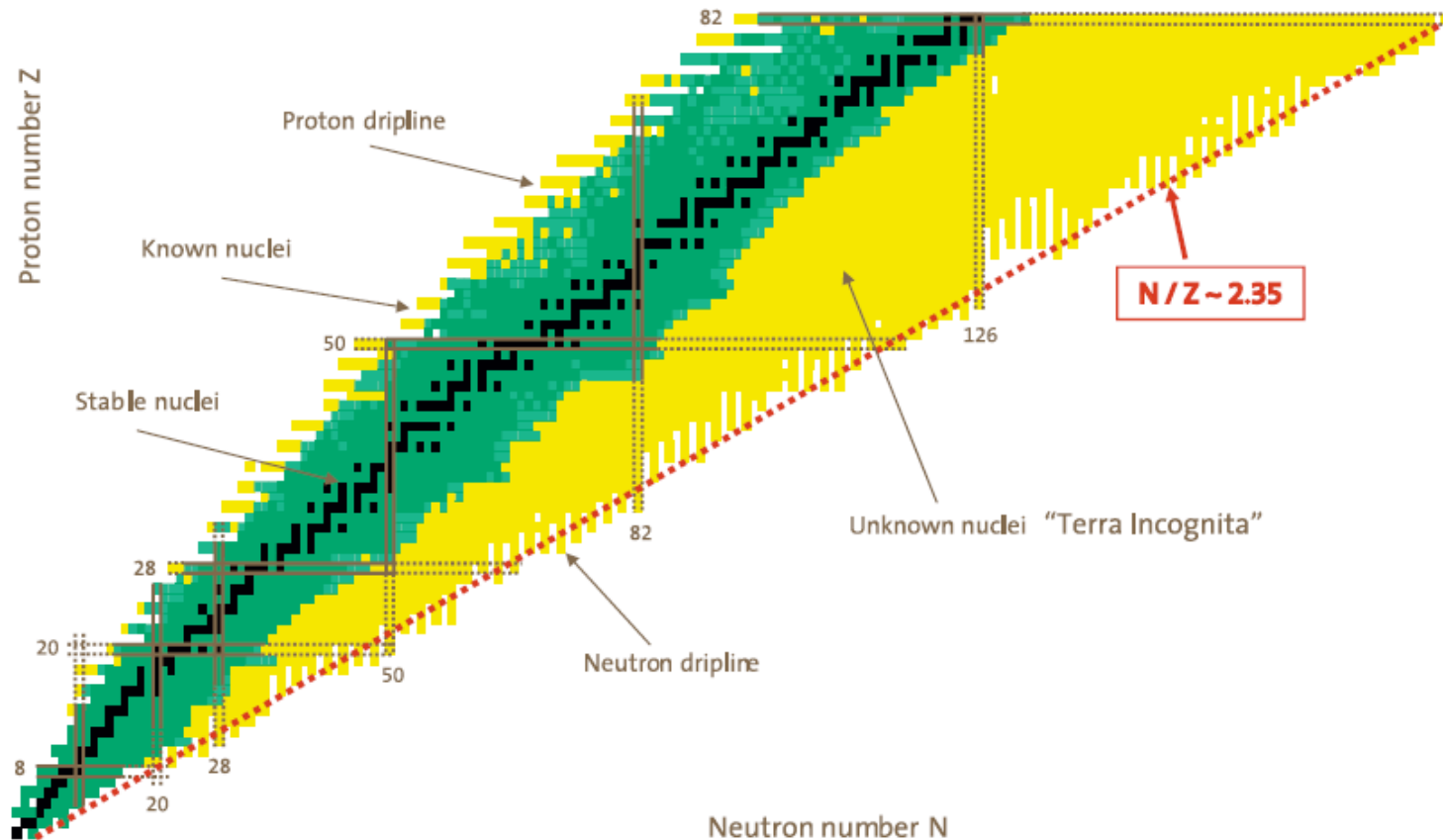
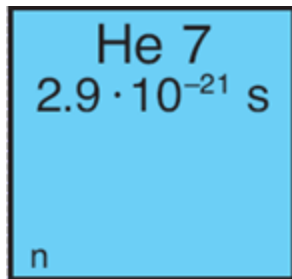
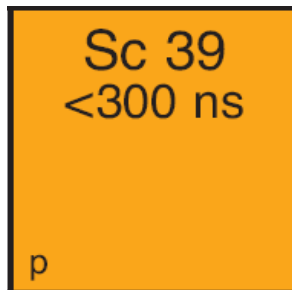


- ➔ Indicator of progress
- ▣ ➔ Number of Nuclides
- ▣ ➔ Number of Elements
- ➔ Radioactivity Modes
- ➔ Decay Data

- ➔ Between the first edition and the 7th edition the number of nuclides has increased from 1300 to 3000. Theoretical predictions are expecting 6000 possible ground-state nuclides



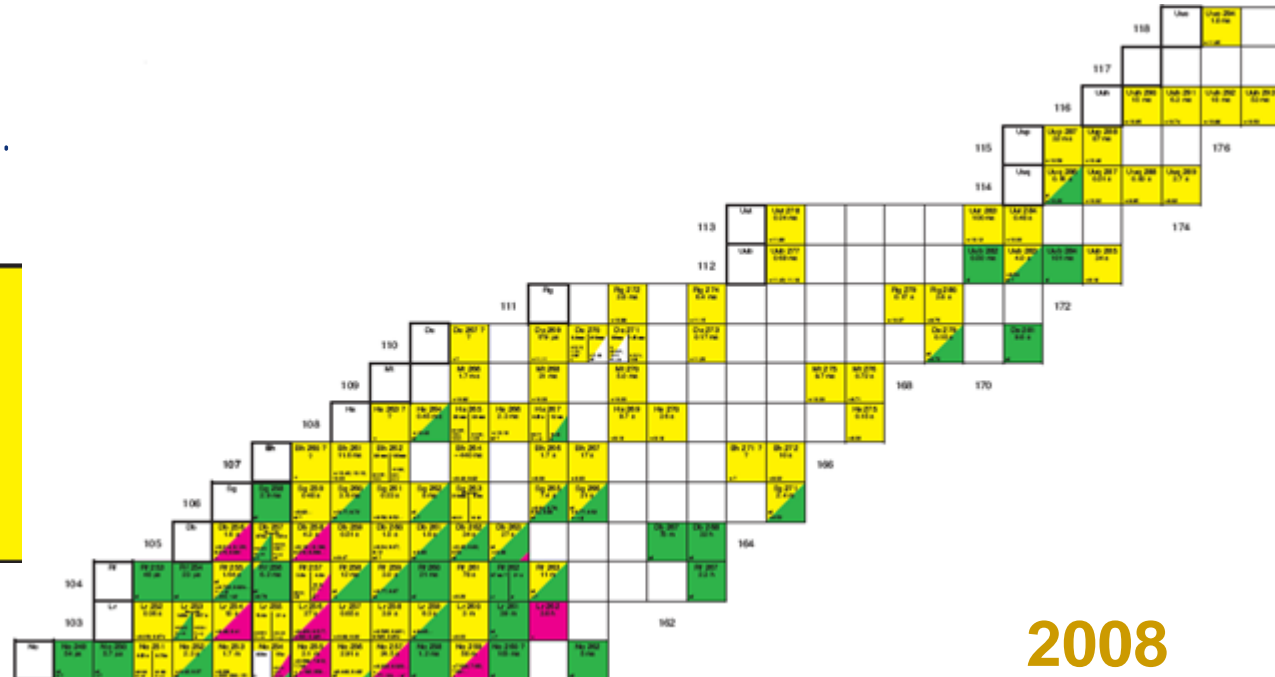
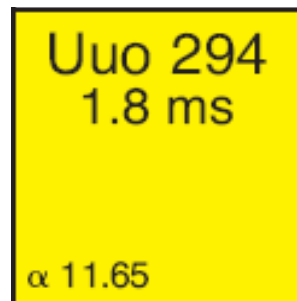
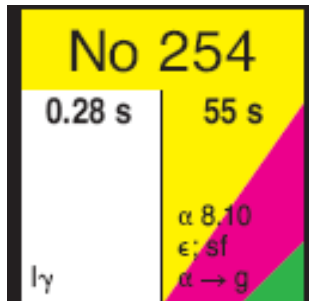
beta decay on both sides



When number of protons or neutrons are too important ➡ unbound nuclides  
Undiscovered nuclides up to these driplines

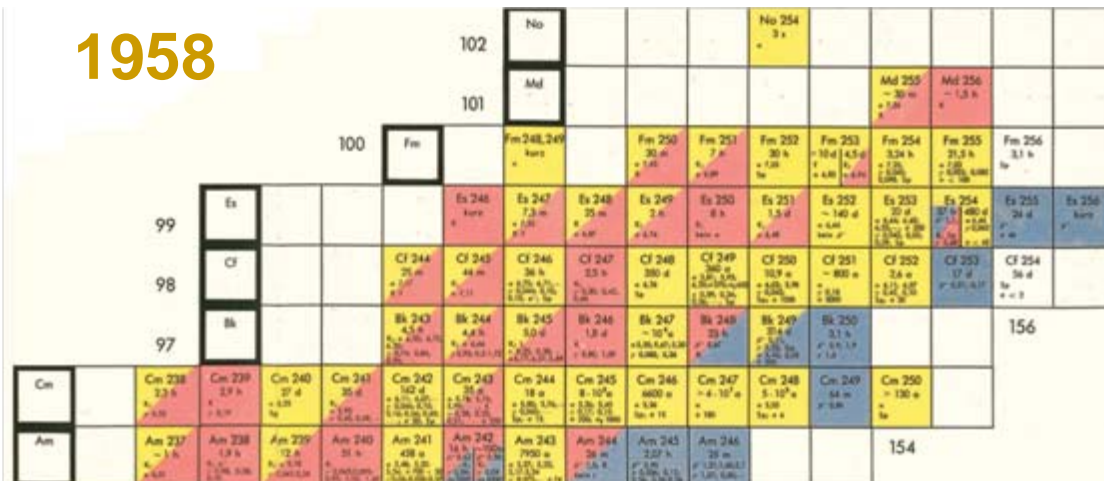


- ➡ Element up to 118 (Ununoctium)  
Element 117 has not yet be discovered.

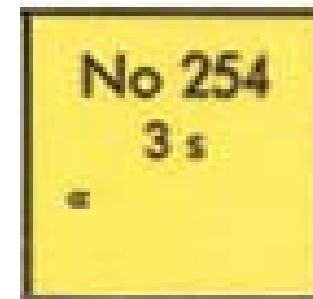


# 2008

# 1958



- ➡ Element up to 102 (Nobelium)



Nuklidkarte



Needs for Nuclear Data (Computer power)

⇒ space exploration, fusion, virus therapy,  
Astrophysics, ...

⇒ Nuclear “Renaissance”

Various projects, JEFF(NEA), AIEA

New up-to-date editions (2010?)



New world dynamics

⇒ India, China, Brazil, Argentina, ...

⇒ New facilities (IMP)

Internationalization with 11 languages